# COUNTDOWN ACID RAIN

# Summary and Analysis of the Third Progress Reports by Ontario's Four Major Sources of Sulphur Dioxide

Environment Ontario

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# COUNTDOWN ACID RAIN

## SUMMARY AND ANALYSIS

## OF THE THIRD PROGRESS REPORTS (JULY 31, 1987)

## BY ONTARIO'S FOUR MAJOR EMITTERS OF SULPHUR DIOXIDE

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## INTRODUCTION

Ontario's Countdown Acid Rain program (announced in December 1985) reduces province-wide emissions of sulphur dioxide ($SO_2$) to 885 kilotonnes (thousand metric tonnes) by 1994, from the 1980 base case level of 2,194 kilotonnes.

Ontario's Countdown Acid Rain non appealable regulations for the four corporate sources which produce about 80% of Ontario's $SO_2$ emissions require staged reductions coming into effect in 1986 and being fully implemented by 1994. The regulations require the companies to file reports each six months, leading up to the final report by the end of 1988 (end of January 1989 in the case of Ontario Hydro) which will show precisely which abatement methods and technologies have been chosen and will detail the socio-economic implications. A complete description of Ontario's acid gas control program can be found in the Countdown Acid Rain information kit available through the Ontario Ministry of the Environment Communications Branch (416 323-4321).

Ontario's four major $SO_2$ sources are Inco Ltd. and Falconbridge Ltd. (nickel/copper smelters in Sudbury), Algoma Steel Corporation Ltd. (iron sintering plant in Wawa), and Ontario Hydro (all its fossil-fuelled electric generating plants across the province).

For 1986, the first full year the Countdown Acid Rain regulations were in full effect, $SO_2$ emissions of all four companies (shown in Table 1) were 294 kilotonnes (kt) below the 1389 kilotonne legal limit permitted by the regulations.

TABLE 1: 1986 $SO_2$ Emissions for Ontario's Major Emitters

| | Legal Limit (kt) | Actual Emissions (kt) | Percentage of Annual Limit (%) |
|---|---|---|---|
| Algoma (Wawa) | 180 | 100 | 56 |
| Falconbridge | 154 | 90 | 58 |
| Hydro | 370 | 270 | 73 |
| Inco | 685 | 635 | 92 |
| TOTALS | 1,389 | 1,095 | 79 |

As of August 1987 each of the four major $SO_2$ sources has submitted three progress reports showing its progress to reduce current emissions and its plans for the required future reductions. Copies of all the reports and the government's summary and response are available from the Ministry of the Environment.

## SUMMARY OF THE THIRD PROGRESS REPORTS

Technical progress continues to be made on several fronts. Detailed financial information is not yet available for most of the needed technical changes, but this is as expected because much of the technology development is not complete, and the companies' final decisions await the results of commercial-scale testing. The final reports, (due when the three year technology development period provided for in the Countdown regulations ends December 31, 1988), must contain the technical and full financial details showing how the emission reductions will be accomplished.

**INCO LTD.**

In Sudbury, Inco operates its large nickel/copper smelter with associated mining and milling operations, and manufactures sulphuric acid from the sulphur associated with the desired metals in the ores. While the company has reduced its $SO_2$ emissions from 1991 kilotonnes in 1970, at the 1986 emissions rate of 635 kilotonnes (while 50 kilotonnes under the legal limit) Inco remains as one of the largest emitters of $SO_2$ in the world.

The company was required by the Ontario Regulation 660/85:

- to limit its $SO_2$ emissions to 685 kt effective 1986,
- to examine the possibility of reaching a limit of 525 kt by 1990 and 175 kt at an unspecified date, and
- to reduce its emissions to 265 kt by 1994.

$SO_2$ emissions at Inco are high, not only because of the very large scale of the operations, but also because of the uniquely high sulphur content in the ore resulting from the presence of pyrrhotite. The sulphur input to the smelter, and therefore the amount of $SO_2$ generated in the smelter, is determined by the amount of pyrrhotite rejected during the milling operations. Inco currently mines 11 million tonnes of ore per year containing 1.1 million tonnes of sulphur. If none of the sulphur was rejected or fixed and it was all oxidized to $SO_2$, emissions would be 2.2 million tonnes. As shown in Table 2, some 63% of the sulphur in the ore is rejected during current milling operations. (Additional amounts are fixed in the smelter).

## SUMMARY OF INCO'S THIRD PROGRESS REPORT

The third report confirms that the current research and testing continues to focus on improving the rejection of the sulphur in the crushed ore before it enters the smelter, while at the same time increasing the metal concentrate grade and minimizing the loss of metal in the rejected material which goes to the tailings ponds. As these processes become more successful, less sulphur will enter the smelter and a higher percentage of the sulphur captured from the hot gases will come from roasting the nickel and copper, and less from roasting of currently non-economic pyrrhotite (an iron sulphide rock containing only small amounts of nickel, copper and cobalt). Then less new acid plant capacity would be needed to meet the lower $SO_2$ emission limits. This is desirable because sulphuric acid shipped from Sudbury is currently not a profitable product.

Over the past five years, productivity in the smelter has been greatly improved as a result of a number of technical changes. In developing solutions to the $SO_2$ emission reduction requirements Inco intends to utilize these efficient facilities to the maximum, and to avoid the construction of a new smelter which would not be cost justifiable (based on Inco studies).

Among the $SO_2$ reduction technologies evaluated by Inco, the only viable approach which will meet the stringent 1994 $SO_2$ emissions limits (265 kilotonne per annum) at an annual nickel production level of 240 million pounds is increased pyrrhotite rejection combined with bulk smelting in a flash furnace. There are still uncertainties to be resolved but it is clear that for Inco to accomplish this all these requirements must be met:

a) Increased pyrrhotite rejection must be possible.

b) Bulk smelting metallurgy must work.

c) Gases from matte separation copper sulphide smelting must be fixed.

d) Gases from the matte separation fluid bed roasters must be fixed.

The company has reported work is in progress in each of these areas.

The company reported that to achieve the even lower level of emissions below 175,000 tonnes p.a. would require the capture of a portion of the converter off-gases, the most difficult option available.

The pace of research and development activity associated with the $SO_2$ abatement program is accelerating and a listing of project and test activities to be conducted in the second half of this year is included in the progress report.

Inco reported that expenditures on $SO_2$ abatement and associated research and development have now exceeded $100 million in this decade and provided an itemized listing.

1. Enhanced Pyrrhotite Rejection System

The pyrrhotite rejection system which separates the sulphur-containing non-magnetic pyrrhotite from the smelting process while keeping the loss of valuable minerals (nickel and copper) to an acceptable level, is being further refined. The pyrrhotite rejection processes

reduce the amount of sulphur which would otherwise have to be emitted or captured and converted to sulphuric acid at a later stage in the process. Inco has provided a number of tables which detail the influence that enhanced pyrrhotite rejection will have on $SO_2$ generation and capture. The reader is encouraged to consult these for details.

Inco converted one sixth of the Copper Cliff Mill non-magnetic pyrrhotite circuit into a "test circuit" to further test a process which had shown encouraging results in pilot plant and laboratory testing.

The test circuit was commissioned during April, and operated under conditions previously defined in Inco's Mineral Dressing Test Centre. However similar metallurgy was not duplicated and rejection of 50-60% pyrrhotite to tailings resulted in high nickel losses. Reagent additions are being varied and circuit modifications are being advanced as testing proceeds. Greater detail will be available for analysis in the next report.

Inco reported that it was studying a scheme to concentrate milling operations at Clarabelle Mill, which may provide for improved pyrrhotite rejection.

2. Bulk Smelting

Currently, most of the nickel and copper move through separate circuits as nickel or copper concentrates. Flash smelting of bulk concentrate (in which copper and nickel ores are not separated but rather are smelted together) increasingly seems to be likely to become the cornerstone of Inco's smelter improvement/$SO_2$ abatement program.

Inco carried out a full scale test of its bulk smelting process using a flash furnace over a three week period beginning in late May. While the detailed test results were not ready for inclusion in the July progress report, the test was characterized in these generalized statements:

> "metal losses in the slag appear to be normal"
> "no serious operating problems were encountered"
> and
> "some process problems still need to be resolved."

Clearly Inco feels early indications are encouraging. The company indicated that the test results will be reported in the fourth progress report.

3. Reverberatory Furnace Reduction Smelting Test

The analysis of the reverberatory furnace reduction smelting test carried out in December 1986 was reported in detail. The test was designed to determine whether more concentrate could be roasted at the Iron Ore Recovery Plant to determine whether the existing reverberatory furnaces might provide a low cost route to $SO_2$ emission abatement, using reduction smelting techniques. A number of major technical problems developed quickly which led to the test being aborted on day five. It appears that smelting high calcine blends with conventional feeding arrangements is not feasible. Further test work will be conducted using a flame smelting burner which is being developed.

## ONTARIO GOVERNMENT RESPONSE TO INCO'S THIRD PROGRESS REPORT

**The technical committee which examined Inco's third report (July 1987) found it complied with the reporting requirements of Ontario Regulation 660/85. The report provided considerable information on the results of experiments and testing carried out by Inco to develop and refine the technologies and processes which it will utilize to meet the progression of reduced emission limits in the regulation.** The report responds satisfactorily to the suggestions relating to projections for emissions reductions and a timetable, as requested in the government's response to the second progress report. Suggestions arising out of the review of the July 1987 progress report were:

- For the sake of clarity the company might consider providing a further table detailing the $SO_2$ fixation levels and associated resulting $SO_2$ emissions to the atmosphere for the data presented in Table 5 of the July '87 report.

- If one of the four requirements cannot be successfully met then alternate technologies and/or reduced production levels will be necessary to meet the emission target. Hence, capturing a portion of the nickel/copper converter off-gases may be required to get down to that target. Consequently, as part of the contingency plan, capture of a portion of the converter off gases should be further explored even though it is seen to be the most difficult option available.

## SUMMARY OF FALCONBRIDGE'S SECOND PROGRESS REPORT

Falconbridge Ltd. operates a large nickel/copper smelter and ancilliary facilities and produces sulphuric acid from the sulphur contained in the ore. The regulation passed in December 1985 (O. Reg. 661/85) requires the company to reduce the $SO_2$ emissions from its Sudbury smelter complex to no more than 100 kilotonnes by 1994. The current limit is 154 kt.

The July '87 report confirms that the emphasis of Falconbridge's five year research and development plan has not been changed. The envisioned methods to meet the lower emission limit are a combination of:

- increased pyrrhotite rejection at the Strathcona mill;
- increased degrees of roasting in the fluid bed roasters in the smelter to produce additional sulphuric acid;
- converter slag cleaning improvements to increase metal recovery.

As suggested in the government's review of the second progress report the company has provided the estimates of the $SO_2$ emission reductions for this strategy.

Projected Sulphur Dioxide Emissions Reduction with Increased Degrees of Roast and Increased Pyrrhotite Rejection at a Production Rate of 88 Million Lbs. of Nickel and 80 Million Lbs. of Copper

| | $SO_2$ Emissions (kilotonnes/yr) | % Reduction |
|---|---|---|
| 1) Current Allowable $SO_2$ Emissions till 1993 | 154 | Base Case |
| 2) With Pyrrhotite Rejection Only | 136 | 12.0 |
| 3) With 64% Sulphur Removal in Ni-Cu concentrate roasting | 109 | 29.0 |
| 4) By combining (2) and (3) | 88 | 43.0 |

For Falconbridge to increase production equivalent to 88 million pounds of nickel before 1993 with present $SO_2$ control processes the current $SO_2$ emissions limit of 154 kt/yr placed on them by the Ministry of the Environment's regulation would be exceeded.

1. Increased Pyrrhotite Rejection

The objective of the program is to reduce the nickel losses associated with the rejection of pyrrhotite from the milled ore. The physical separation of grains of pentlandite (the main nickel ore) from nickel bearing pyrrhotite is very difficult to achieve. Consequently, incremental improvements are being sought in several areas.

The new magnetic separation and flotation circuit on the scavenger concentrate at the Strathcona Mill is now operating well and producing less nickel in pyrrhotite concentrate. A conceptual design of a process control system was completed and an upgrade of the "On-Stream" x-Ray Fluorescence Analyser was initiated. Major control strategies in grinding and classification were developed for testing.

A pilot test of newly developed flotation column and large flotation cells is proceeding. A techno-economic model was completed to assist mill flowsheet changes on the economics of pyrrhotite/pentlandite separation versus increased degrees of roasting.

2. Increased Degree of Roast

The objective is to increase the degree of sulphur elimination during roasting and to capture the extra $SO_2$ as acid in the existing smelter.

The progress report confirmed that increased degrees of roast projects proceeded in these areas:

- reducing air infiltration in the roaster off-gas system
- designing alterations to the cyclone system to reduce pressure drop
- designing methods to improve the electrostatic precipitator reliability and efficiency
- conducting engineering studies of the acid plant unit operation capacities
- designing buildup control systems on the roaster flues

As well work proceeded on these projects to treat the calcine product from the increased roasting in order to achieve higher metal recoveries:

- engineering design of copper cooler installation on the electric furnace
- simulating and evaluating improved process control in converting.

As well these in-plant test modifications were planned for the July-August shutdown including:

- installation of 269 copper coolers on the electric furnaces
- bypassing the secondary cyclones
- improving the electrostatic precipitator discharge electrodes
- modifying several air infiltration areas.

The new converter slag cleaning process continued to be developed with potential developments in process control, refractories and alternate reductants.

## ONTARIO GOVERNMENT RESPONSE TO FALCONBRIDGE'S THIRD PROGRESS REPORT

The technical committee found that the reporting requirements of Regulation 661/85 were met. Falconbridge's progress and approach seem reasonable particularly since they already have the hardware needed for reduction smelting technology. The company incorporated detailed responses to the reviewers' suggestions after reviewing the last report.

## SUMMARY OF ALGOMA'S THIRD PROGRESS REPORT

The Algoma Steel Corporation Ltd. operates an iron sintering plant in Wawa. Regulation 663/85 limits the $SO_2$ emissions from the operation to 180 kilotonnes per year in 1986 through 1993, and to 125 kt in 1994 and thereafter. The previously existing limit was 285 kt.

As of August 1, 1986, Algoma Ore Division has decreased its production capacity at Wawa from 2.0 million tons per year to 0.9 million tons per year. Consequently, $SO_2$ emissions will be maintained well below the 1994 requirement of 125 kilotonnes.

The third progress report confirmed that there had been no change to the economic realities facing the steel industry so the company would continue its Wawa operations at reduced capacity. Should market conditions change, the company would obtain ore from sources other than Wawa.

**ONTARIO GOVERNMENT RESPONSE TO ALGOMA'S THIRD PROGRESS REPORT**

**The technical committee found that the reporting requirements of Regulation 663/85 have been met with respect to the company's third progress report.** Also noted:

- If economic conditions change and the company wishes to increase its production at Wawa again, utilizing any ore containing sulphur, acid gas reduction methods or procedures such as those previously examined would have to be in place before production could significantly increase.

**ONTARIO HYDRO**

Ontario Hydro currently operates coal-burning electrical power generating stations at five locations in Ontario. Three major plants are in southern Ontario, and two smaller plants are in the north-west part of the province. Other fossil-fuel plants are currently moth-balled (two oil-fired units near Kingston will be re-activated December 1987 for possible use). Nuclear and hydraulic plants supply over two-thirds of the electrical power in the province, and the coal-fired plants largely supply power to cover peak demands.

Regulation 662/85, passed in December 1985 as part of the Countdown Acid Rain regulatory package prescribed a schedule of reductions in the $SO_2$ legal limits, which are cut from 370 kilotonnes in 1986 to 240 kt in 1990 and to 175 kt by 1994. Limits were also placed on the sum of $SO_2$ plus oxides of nitrogen ($NO_x$).

In May 1987, Regulation 662/85 was replaced by Regulation 281/87. This new tighter regulation removed the emission banking provision which would have allowed Hydro to bank shortfalls in emissions below the regulated limit, for use in subsequent time periods. This change was made in response to the report of the Select Committee on the Environment.

No change was made to the actual emission limits specified in the previous regulation, but the removal of flexibility for Hydro will require further abatement actions to ensure that the legal limits are met at all times.

The new regulation also changed what had been the voluntary submission of six-monthly abatement progress reports to a formal regulatory requirement.

## HYDRO'S THIRD PROGRESS REPORT

Ontario Hydro reports that acid gas emissions for the first six months of 1987 were estimated at 150,600 tonnes of $SO_2$ and 28,800 tonnes of $NO_x$. In the similar six month period of 1986, emissions were 154,500 tonnes of $SO_2$ and 28,600 tonnes of $NO_x$. Drought conditions in Ontario resulted in a decline in hydraulic production and a compensating increase in coal-fired production of 16% above forecast. Despite this, emissions remained about the same.

The report notes that the removal of the emissions banking provisions "will have a significant impact on Hydro's control program and is being evaluated".

Hydro had previously reported the approval of $7.7 million for research and preparation of a program Environmental Assessment in anticipation of the need to retro-fit flue gas desulphurization equipment on selected coal-fired generating units. The third progress report notes that public meetings have subsequently been held at locations close to the Nanticoke, Lambton and Lakeview generating stations, as well as with the provincial interest groups at Hydro's head office. The formal Environmental Assessment document is being prepared and comments from the Ministry of the Environment had been received on the first four chapters.

## ONTARIO GOVERNMENT RESPONSE TO ONTARIO HYDRO'S THIRD PROGRESS REPORT

**The Technical Committee found that Hydro's third progress report has satisfied the formal requirements of the new regulation (O. Reg. 281/87). It was noted and appreciated that actual acid gas emissions have been kept well below the legal limit, and that activity has continued with respect to Environmental Assessment procedures, to ensure that Hydro is in a position to retro-fit scrubbers.**

Hydro must meet the emission limits specified by the regulation and the corporation has stated it will do so. In future reports, it would be helpful if Hydro were to provide greater context for the direct abatement actions which are under way, by discussing other options more fully. These could include electricity conservation measures, parallel generation incuding co-generation, purchases or development of indigenous hydro-electric power, increased use of low sulphur coal or new clean coal technologies, and potential for natural gas as a replacement fuel for coal.

Up-dated information on actual and projected demand growth would also be helpful.